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AUTHOR Clark, Sheldon B.; Finn, Michael G.
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INSTITUTION Oak Ridge Associated Universities, Tenn.
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ABSTRACT

A study is proposed that seeks to use the normally problematic factor of non-response to a survey in a positive way in order to estimate certain characteristics of a population subgroup. A longitudinal database, the Scientific and Technical Personnel Data System (STPDS) measures the educational, demographic, and employment characteristics of the nation's scientists and engineers. An examination of response trends for STPDS surveys reveals that response rates for foreign-born scientists and engineers deteriorate at a faster rate over time than do the response rates of those born in the United States. It is hypothesized that emigration accounts for these differences, and that the difference in the rates of decline of response rates can be used as a proxy for emigration of scientists. Two very different approaches have been developed and will be used to test the hypothesis and to validate the proposed technique. Although this methodology is not generalizable to all surveys, it does illustrate the importance of a researcher's being thoroughly familiar with the survey population and the importance of being open to the possibility that challenging and testing the precepts of the practice of survey research can result in improvements in methodology. Three bar graphs give information about the proposed study. (SLD)

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Sheldon B. Clark
Oak Ridge Associated Universities

Michael G. Finn
National Research Council

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Interpreting Nonresponse in Survey Research: Methodological Heresy?

Introduction

Of all the potential sources of bias associated with survey research, one of the most troubling is nonresponse. One indication of the degree of seriousness of this problem is the amount of textbook and journal space devoted to the presentation and testing of various survey techniques that can be used to stimulate response. Another indication of the significance of the problem is the attention given to measuring the bias associated with nonresponse. Although the true effect of actual nonresponse cannot be known, the literature is replete with alternative ways of evaluating its probable effect on parameter estimates.

It is not the purpose of the present paper to review the various approaches that have been proposed to decrease nonresponse or to evaluate or estimate the direction and/or magnitude of the biases associated with nonresponse. The reader who is interested in exploring alternative techniques for accomplishing such objectives is referred elsewhere--for example, to an excellent three-volume report issued by the Panel on Incomplete Data, Committee on National Statistics, National Research Council (Madow et al., 1983), which includes a rather comprehensive bibliography covering many nonresponse issues. Additional general coverage can be found in a well-organized but somewhat outdated publication by the Census Bureau (U.S. Bureau of the Census, 1974).

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The present paper focuses on a study that seeks to use the normally problematic factor of survey nonresponse in a positive way--to estimate certain characteristics of a population subgroup. The specific context in which the technique is applied--within the framework of a longitudinal survey--is one that admittedly may not be applicable to many educational researchers. Even those who do not use longitudinal techniques may find the present study to be instructive, however, because it represents an example of an innovative solution to a significant problem, made possible by the investigators' familiarity with their survey population--certainly a lesson that can benefit all survey researchers.

The Nature of the Problem

Context

The National Science Foundation Act of 1950, as amended by Title 42, United States Code, Section 1862, mandates that the National Science Foundation (NSF) obtain and provide current information about the nation's scientists and engineers. One of the primary mechanisms by which NSF fulfills this obligation is by maintaining, updating, and improving a longitudinal data base, the Scientific and Technical Personnel Data System (STPDS), which is designed to measure the educational, demographic, and employment characteristics of the nation's scientists and engineers. (Details about the three individual surveys which comprise the STPDS and how they are integrated to produce national estimates are not relevant to the purposes of this paper. The reader who is interested in learning more about the technical characteristics of this data base is referred to NSF's Guide to Science/Engineering Data.)

U.S. reliance on foreign-born scientists and engineers in certain disciplines--particularly those individuals holding advanced degrees--is well-established (Finn, 1985; Finn, 1987; National Research Council, 1988). Monitoring the flows (i.e., immigration and emigration) of these professionals, therefore, is important for

assessing the size and characteristics of the population of scientists and engineers in the United States. Unfortunately, during the past 10 or 15 years, the resources devoted to the careful tracking of immigration and emigration of all kinds have declined significantly in this country (Levine, Hill, & Warren, 1985). As a result, innovative, low-cost techniques for estimating the number and movement of foreign-born scientists and engineers into and out of the United States are needed. Although both sides of the science and engineering personnel flow "equation" (in-flows as immigrants and out-flows as emigrants) are important, it is the emigration component that is the focus of the present paper.

Emigration data are not routinely collected by the U.S. government. If such data were collected they would probably be of limited value, because persons leaving the United States may not give accurate answers to questions about their intentions to return. Thus, it is very difficult to distinguish the emigrant from the person who is leaving only temporarily for vacation or work. Given the extreme difficulty of measuring emigration in general, measuring that of a subgroup of the population--scientists and engineers in this case--becomes even more difficult.

Problems Associated With Survey Nonresponse in the Target Population

Emigration is not taken into account. It is thought that many immigrant scientists and engineers do not stay in the United States until they retire (Finn, 1985). To the extent that they do in fact emigrate after a short stay in this country, the STPDS is designed in such a way that an overestimate of the number of foreign-born scientists and engineers in the United States is almost certain to result. This overestimate arises from the way survey nonrespondents are treated in obtaining population estimates: the weights of the respondents are increased to compensate for the nonrespondents in a given stratum, so that the number of weighted observations in a stratum cannot be affected by nonresponse alone.

The estimation procedure is a "closed system" in this regard; in effect, it is not possible for a nonrespondent to leave the target population.

Because the STPDS is a longitudinal data base and because the sampling and stratification involved in the constituent surveys are very complicated, the nature and magnitude of biases introduced through such estimation procedures are impossible to predict for particular characteristics of groups meeting specified demographic criteria. If foreign-born immigrants tend to emigrate during the period of the survey, the "closed" nature of the system will lead to observations with higher and higher weights for those who do respond. The use of these large-weight observations in analyses involving relatively few raw observations consequently become less and less reliable.

Erroneous conclusions may be drawn. The effect of sample weights for respondents increasing over time can be illustrated in some data (based on a weighted analysis of one of the surveys which make up the STPDS) that were presented to support the contention that engineering schools in U.S. universities are increasingly relying on foreign-born engineers to fill new faculty vacancies (See Figure 1). Though it is certainly possible that the trend in Figure 1 represents the true state of affairs, it is far more likely that the magnitude of the change depicted is exaggerated by the treatment of nonresponding immigrants described above, since there was a large rise in the nonresponse of foreign-born members of the survey population during the years considered in the analysis.

Hypothesis

An examination of response trends for the relevant STPDS surveys reveals that the response rates of foreign-born scientists and engineers deteriorate at a faster rate over time than do the response rates of U.S.-born scientists and engineers. For example, Figure 2 shows the overall fall-off in response rates for the Survey

of Doctorate Recipients (one of the STPDS surveys) between 1981 and 1983 and between 1981 and 1985 for various citizenship classifications. *It is important to note that all of the individuals represented in this figure responded to the 1981 survey.*

Figure 3 depicts an even more dramatic difference among citizenship categories and is perhaps even more relevant to the issue at hand. Whereas Figure 2 includes responses that were received from foreign as well as U.S. addresses, Figure 3 includes only those responses received from U.S. addresses. It is plausible that the responses from foreign addresses are much more likely to include individuals who will not return to the United States and are, therefore, not appropriately considered to be part of the stock of U.S. scientists and engineers.

We propose that the differential decline in response rates between U.S.-born and foreign-born scientists and engineers be attributed to emigration and that the difference in the rate of decline be used as a proxy for emigration. Let us first examine the rationale for this interpretation and then suggest procedures for testing the hypothesis.

Rationale for Nonresponse Interpretation

Control for initial differences in attitudes towards surveys. The most convincing explanations one hears when considering the response rate differences that commonly occur between U.S.-born and foreign-born survey recipients seem to focus on such ingrained personal characteristics as cultural differences and different senses of obligation (or suspicion) associated with government surveys. In the present context these differences are in some sense "controlled for" by starting with a group of individuals all of whom responded to the survey in the base year (e.g., 1981 for the Survey of Doctorate Recipients). Though there are many reasons that could account for the observed differences in response rate deterioration

between U.S.-born and foreign-born scientists and engineers, the authors contend that the most important of these other causes can account for only a trivial difference between the two groups, because the willingness-to-respond "control" lends more credence to the emigration interpretation.

Relative propensity to emigrate. Finn (1985) found that fewer than 20 percent of foreign-born scientists and engineers came to the United States at an early enough age to attend secondary school here. Most of the foreign-born scientists and engineers were educated and socialized in foreign countries, and often they received undergraduate college degrees from foreign universities. They are fluent in foreign languages and are able to function as natives in other cultures. As such, they are much more employable in foreign countries than is the average U.S.-born scientist or engineer. The foreign-born are also more likely to have relatives abroad. Some foreign-born scientists and engineers are obligated to return home and/or have difficulty staying in the United States. For these and for other reasons, the foreign-born scientists and engineers in the United States are likely to have a positive emigration rate.

The U.S.-born leave the United States too, but mostly for temporary assignments in foreign countries. Available evidence does not support the view that there is substantial net emigration of U.S.-born scientists and engineers. Consider the case of the United Kingdom, which, because of language and the prestige of its scientific institutions, may be the most popular destination for U.S. scientists and engineers leaving the United States. A recent study by the Royal Society (1987) identified by name 685 science or engineering immigrants to the United Kingdom over the past ten years. Of these, only 76 (11 percent) were from North America, some of whom we may assume were from Canada. Further, the Royal Society reports that most of those counted as arriving during the preceding ten years were no longer in the United Kingdom at the time of the survey. Ignoring the fact that some must be from Canada and that some may not have doctorates, the immigration recorded by the

Royal Society could have been produced by a ten-year emigration rate of 0.01 percent of the U.S. population of doctoral scientists and engineers.

Of course, emigration from the United States to the United Kingdom is only part of the total U.S. emigration of scientists and engineers. We know, however, that the United Kingdom is one of the most popular sites for Americans who go abroad for scientific visits (Finn & Sigmon, 1988). It seems likely, therefore, that any permanent emigration of U.S.-born scientists and engineers would involve the United Kingdom at least as frequently. If this assumption is accepted, we could extrapolate from the Royal Society study to conclude that emigration of U.S.-born scientists and engineers is probably less than ten times the emigration to the United Kingdom, and thus that the total emigration rate for this group is probably no more than 0.1 percent.

Becoming acculturated. In general terms, one would expect that the longer a foreign-born person stays in the United States, the more he/she would tend to adopt the attitudes and behaviors of U.S. natives. That being the case, one would expect naturalized U.S. citizens to act more like U.S. natives than non-U.S. citizen permanent residents. Likewise one would expect non-U.S. citizen permanent residents to behave more like U.S. natives than non-U.S. citizen temporary residents. In terms of response to the 1981 Survey of Doctorate Recipients, this is generally the case. Making no assumptions about the relative likelihood of actually being contacted, the 1981 response rates for U.S. natives, naturalized U.S. citizens, non-U.S. citizen permanent residents, and non-U.S. citizen temporary residents were 69%, 78%, 36%, and 8% respectively. (Bear in mind, however, that this has no relationship to Figures 2 and 3.)

As far as the likelihood of an individual's leaving this country is concerned, we would expect the same relationship to hold: we would expect the groups that have more ties to the United States (e.g.,

career, financial investments, friends, family, interests) to exhibit a lower propensity to emigrate than those who have fewer of those ties. As we have seen above, very few U.S. natives emigrate. Figures 2 and 3 reflect the patterns that one would expect with regard to the other citizenship classifications.

Rival hypotheses. Why might a person respond to the survey in 1981 but not in 1985? Many possibilities exist, but several major reasons merit consideration: he/she (1) died; (2) retired; (3) moved within the United States and the questionnaire was not forwarded; (4) simply refused to cooperate; (5) left the United States and the questionnaire was not forwarded; (6) received the questionnaire in a foreign land but thought a response might not be needed from a person now outside the United States; or (7) received the questionnaire in a foreign land, could not use the business reply envelope, and did not want to use personal funds to pay the return postage.

It would be difficult to argue that the foreign-born scientist or engineer who had responded in 1981 would be any less likely to respond than the U.S. natives on any one of the first four counts listed. In fact, with regard to death and retirement, just the opposite would more likely be the case. It has been shown that foreign-born scientists and engineers tend to be younger than their U.S.-born counterparts (Finn, 1985). Migration within the United States may differ slightly between the two groups, but no data are available to support this. Most importantly, the authors would argue that there is no reason to expect a higher or lower refusal rate for the foreign-born. As previously stated, there may be a reason for the foreign-born to be more or less likely to respond to surveys like this in the first place, but the sample on which Figures 2 and 3 are based all responded in 1981. This leaves reasons 5, 6, and 7 listed above. Any person who emigrates is less likely to have his/her mail forwarded and is less likely to respond if the questionnaire should reach him/her.

Consistency of observed patterns with expectations. The patterns of response fall-off that were observed are consistent with the above rationale. There is a greater fall-off for non-U.S. natives than for U.S. natives; the fall-off for temporary non-citizens is greater than that for permanent non-citizens; and the fall-off for non-native citizens is greater than that for native citizens.

Validating the Hypothesis

Because the observed patterns of response deterioration could be explained logically for the Survey of Doctorate Recipients, because these patterns held up across the other surveys comprising the STPDS, because there was convincing evidence that the current estimation procedures were not adequate, and because no other acceptable alternative had been developed, the argument outlined above was used to develop preliminary estimates of the emigration of foreign-born scientists and engineers (Finn & Clark, 1988). Inasmuch as the process is more germane to the present purpose than are the outcomes, no space will be devoted to these estimates in this paper. It should be noted, however, that one of the ancillary benefits of this estimation procedure was to decrease the effective nonresponse rate for the foreign-born (since those nonrespondents who were classified as emigrants in the algorithm were no longer legitimately considered a member of the target population).

Inasmuch as the issues raised in the course of the present study have significant implications for the integrity of NSF's Scientific and Technical Personnel Data System and the reliability of the estimates of the stock of U.S. scientists and engineers that are produced from it, NSF has been supportive of the authors' efforts to develop empirical validation of the proposed estimation procedure. Two very different approaches have been developed to test the hypothesis, one of which can be used on one of the STPDS surveys and one of which can be used on two of the surveys. Once all three studies have been carried out, the validity of the proposed technique can be assessed.

Importance of the Study for Survey Researchers

The authors recognize that the methodology presented in this paper is not generalizable (at least in a "wholesale" manner) to surveys in general, or even to longitudinal surveys. They do believe, however, that this study holds several lessons for all survey researchers.

First, it underscores the advantages of a researcher's being thoroughly familiar with his/her survey population. Also, it suggests the value of keeping track of the general characteristics of those who respond to a survey. It is probably a very rare case when an investigator knows nothing about the individuals in his/her survey population and when it is not advisable or not possible to include an identification code so that incoming responses can be tracked. The information that he/she has on the nonrespondents may be useful in gaining some insight into how the respondents compare to the nonrespondents on a few gross demographic variables perhaps. Such an analysis may or may not offer any clues as to what sorts of nonsampling bias may exist, but they might suggest alternative contact or follow-up procedures for present or future use.

More importantly, it is hoped that this paper will encourage survey researchers to accept the "tenets" regarding the practice of survey research with at least a modicum of skepticism, because challenging and testing these precepts can lead to improvements in methodology. The researcher who is haunted by the feeling that his/her survey application is somehow unique and that maybe--just maybe--all of the "golden rules" do not apply, may not be guilty of heresy but only of critical, creative thinking that may eventually lead to the development of solutions to "unsolvable" problems.

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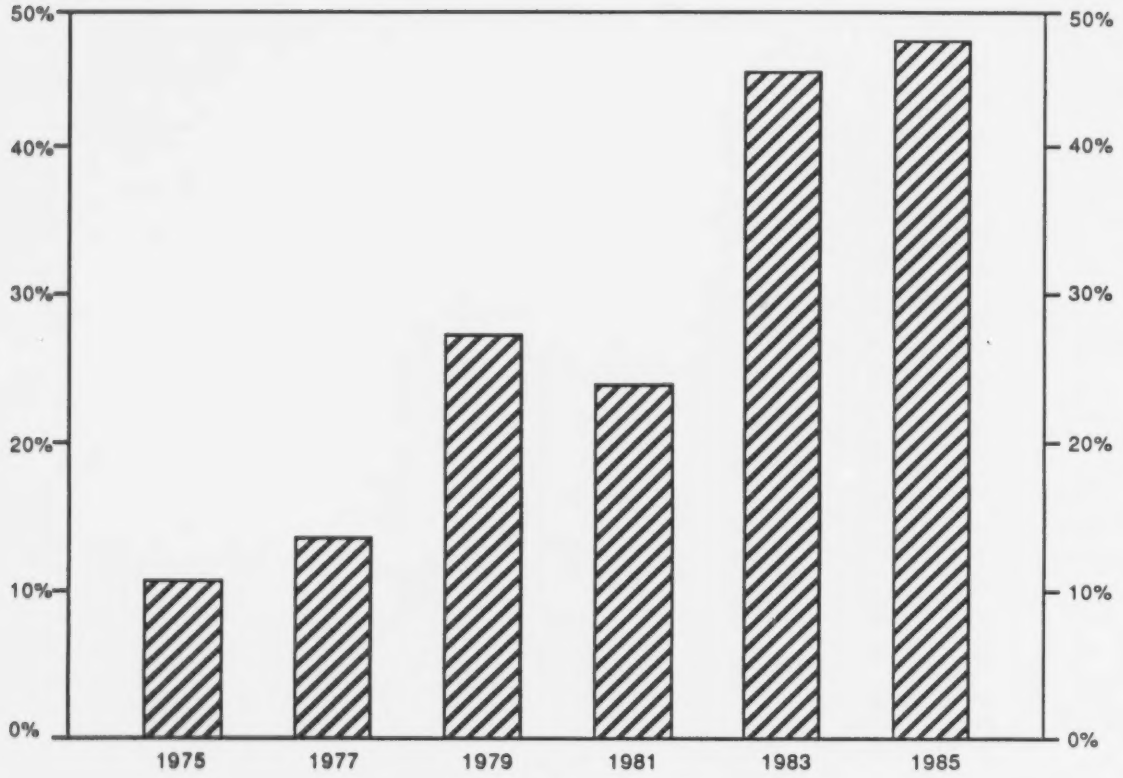
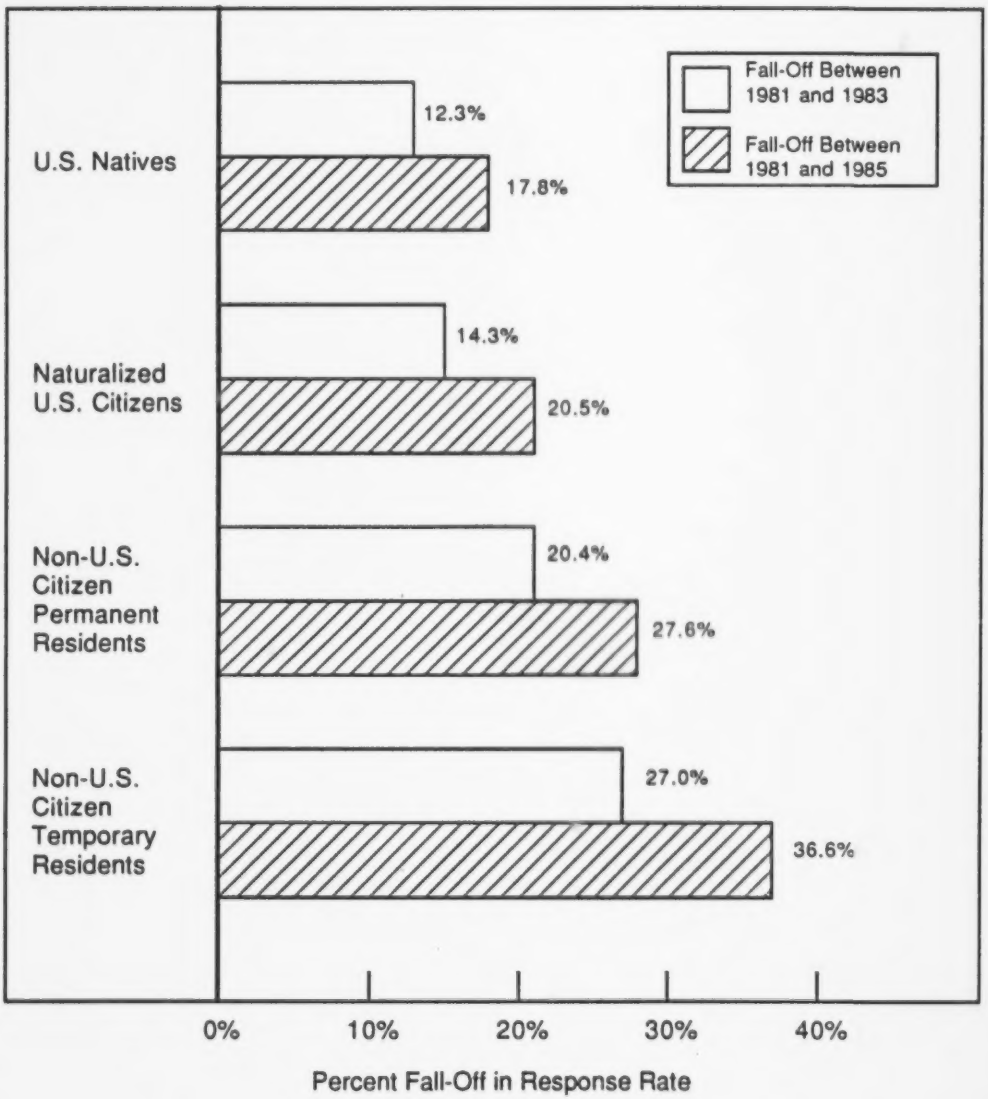


Source: Charles E. Falk. "Foreign Engineers and Engineering Students in the United States." Presented at a workshop sponsored by the Committee on the International Exchange and Movement of Engineers, National Academy of Engineering, Washington, D.C., July 7, 1987.

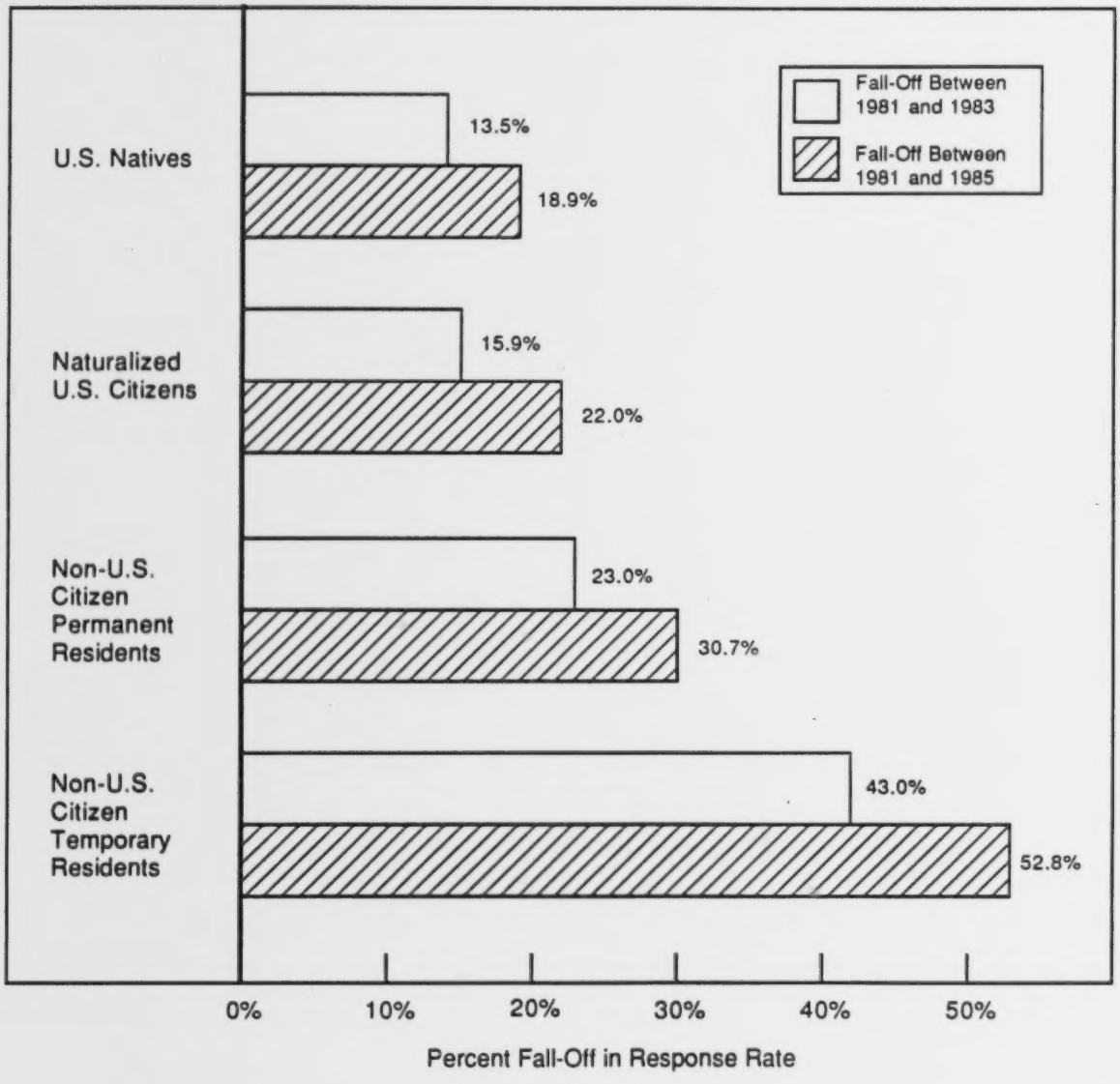
FIGURE 1. FOREIGN-BORN AS A PROPORTION OF ALL ENGINEERING FACULTY, AGED 35 OR LESS



NOTE: Percentage changes are based on unweighted totals.

SOURCE: Based on special tabulations from the National Research Council.

FIGURE 2. CHANGES IN TOTAL RESPONSE RATES BY CITIZENSHIP STATUS FOR THOSE INDIVIDUALS WHO RESPONDED TO THE 1981 SURVEY OF DOCTORATE RECIPIENTS.



NOTE: Percentage changes are based on unweighted totals.

SOURCE: Based on special tabulations from the National Research Council.

FIGURE 3. CHANGES IN U.S. RESPONSE RATES BY CITIZENSHIP STATUS FOR THOSE INDIVIDUALS WHO RESPONDED TO THE 1981 SURVEY OF DOCTORATE RECIPIENTS.